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Availing other disciplines' knowledge about sustainable impact of professional development programmes

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Abstract: *This paper deals with the sustainable impact of innovations and professional development programmes. While research on this issue is rather scarce in educational disciplines (and in particular in mathematics teacher education), some other domains like health care or development aid are well grounded in research results regarding this topic. This article gives an insight into the other disciplines' knowledge concerning the impact of innovations and professional development programmes and the respective fostering and hindering factors. Moreover, possible implications for (mathematics) teacher education are discussed.*

Keywords: Mathematics teacher professional development; sustainability in professional development; Mathematics teacher education; Models of professional development; Inter-disciplinarity in professional development;Austria

Introduction

The study of educational innovation over the long run is a depressing one.

(R. Slavin)

The question of how to promote mathematics teachers' professional development is of great interest and discussed in various papers (e.g., Krainer & Zehetmeier, 2008; Loucks-Horsley, Stiles, & Hewson, 1996; Maldonado, 2002; Sowder, 2007; Zehetmeier, 2010; Zehetmeier & Krainer, 2011). Ingvarson, Meiers, and Beavis (2005) state: "Professional development for teachers is now recognised as a vital component of policies to enhance the quality of teaching and learning in our schools. Consequently, there is increased interest in research that identifies features of effective professional learning" (p. 2).

In this context, the question of sustainability is of particular relevance. Despite its central importance for both, teachers and teacher educators, research on sustainable impact is generally lacking within teacher education disciplines (Datnow, 2006; Rogers, 2003). Hargreaves (2002) resumes: "As a result, many writers and reformers have begun to worry and write about not just how to effect snapshots of change at any particular point, but how to sustain them, keep them going, make them last. The

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sustainability of educational change has, in this sense, become one of the key priorities in the field" (p. 190). Similarly, Colbeck (2002) claims: "Despite its importance to the change process, institutionalization often receives little consideration by organizational participants" (p. 398). Van den Berg (2005) states that "most evaluations focus on short-term or intermediary results of the projects, programmes or policy to be evaluated" (p. 27).

However, a sound knowledge base concerning the issue of sustainability would be useful for understanding the long-term impact of teacher professional development programmes, in particular for mathematics teacher education. At the same time, this knowledge would allow thorough discussions regarding implications for upcoming professional development programmes' planning, implementation, and evaluation. Although some research findings are available (see e.g., Zehetmeier, 2008, 2009) it would be important to enhance further research and evaluation to get new results regarding the sustainability of impact. Slavin (2004) complains: „Most innovations adopted on a large scale were never adequately evaluated in the first place … but even among the small number that have been successfully evaluated, few have been able to maintain themselves in schools over an extended time period. Most often, innovations that have been enthusiastically adopted and even found to be effective in particular schools are later dropped, sometimes to be replaced by other innovations and sometimes for a return to the status quo ante" (p. 61).

In particular, the facilitators of professional development programmes can make use of expertise "to carry out the functions associated with the innovation, as well as with the strategic planning, in order to plan for sustainability. … Knowledge of process and outcome evaluation methods is necessary to assess and understand the effectiveness of the innovation" (Johnson, Hays, Center, & Daley, 2004, p. 144). This is particularly relevant for teacher educators.

The aim of this article is to provide other disciplines' knowledge concerning the sustainable impact of innovations and professional development programmes. For this, an extensive literature was carried out; using qualitative content analysis (Mayring, 2003), relevant topics were identified and clustered; this led to the following categories: the others' rationale, the others' definitions, the others' theories, the others' methods, the others' factors, and the others' discussions. After introducing "the others", each of these categories is provided in the following sections. Then, implications for mathematics teacher education are discussed.

The others

Am I or are the others crazy?

(A. Einstein)

In this paper, the knowledge of other disciplines is provided to discuss some possible implications for mathematics teacher education. This leads to the question: Who are the others? Health care disciplines come with a relative long tradition of researching the topic of professional development's sustainable impact. This led to a widespread body of research findings concerning this issue. Besides the health care disciplines also research on development aid or management research has available interesting findings; they also can be used as focal points for discussing and reflecting sustainability in mathematics teacher education.

Thus, this paper's literature review is based particularly on research findings from health care disciplines (e.g., Scheirer, 2005). Moreover, results from disciplines like development aid (e.g., van den Berg, 2006), management research (e.g., Lawrence, Winn, & Jennings, 2001) or public service evaluation (e.g., Savaya, Elsworth, & Rogers, 2009) are provided.

The others' rationale

The journey of a thousand miles begins with a single step.

(Laotse)

Why do the others this kind of research? This section provides some rationale, why the other disciplines invest time, money and other resources to research the question of sustainable impact of innovations and professional development programmes.

One reason is the improvement of a rather limited knowledge base: While there is rather sound knowledge regarding professional development programmes' implementation or evaluation, the knowledge of programme sustainability "tends to be contradictory and fragmented" (Pluye, Potvin, & Denis, 2004, p. 121). Programme planers, participants, or funders consider this issue to be highly important; but – when going into details – there are rather contradictory recommendations how to sustain a programme's impact over time. Pluye et al. (2004) state: "Little is known about the sustainability process. Consequently, it is difficult for public health practitioners to know how and when to influence the sustainability of 'their' programs" (p. 121).

This limited knowledge base may be due to the fact that "institutionalization[2] is typically assessed superficially, if at all" (Colbeck, 1999, p. 13c1-1). The reason for this lack of research seems to be "that impact assessments, … five or more years after a project or activity has ended, are not easy to undertake, and consequently are not widely undertaken nor widely read" (van den Berg, 2005, p. 27). This includes particularly the claim that "impact assessments … are too costly" (ibid., p. 28): The long-term time horizon makes this kind of research face "historical challenges … if a very wide scope is chosen and historical reconstruction is part of the research. This often requires extended file and dossier research and analysis of historical data" (ibid.).

Another reason for researching the sustainability of programmes is its inherent importance for the programmes' success. Since "many programmes aim at behavioral changes, they must survive over an extended period of time for such changes to occur" (Pluye, Potvin, Denis, & Pelletier, 2004b, p. 489). Moreover, "there is often a latent period … between when programs begin and when their effects on population … are felt" (ibid.).

In this regard, one may discuss the question: What if sustainability of professional development programmes is not considered or achieved? Discontinued programmes bear the potential of bringing disillusion to participants and therefore posing obstacles to subsequent mobilization: "The absence

[2] Colbeck (2002) uses the term institutionalization to refer to sustainable impact; see also section "the others' definitions".

of sustainability would lead to an investment loss for the organizations and people involved" (Pluye et al., 2004, p. 122). Moreover, as van den Berg (2005) claims, if programme evaluation is limited to the study of input, output and the process in between, it can be used as a monitoring tool, but has rather limited value at the impact level: "… Monitoring will tell whether you are doing things right, but not whether you are doing the right thing. Evaluation can, if applied properly, answer the second question. Yet, if evaluation cannot or will not assess impact, or longterm results, will it be able to fulfil this promise?" (p. 28).

Given this range of rationale, a rather typical research question is for example: "What happens after the initial funding for new programs expires? Do the programs continue or end their activities or even expand to new sites or new beneficiaries?" (Scheirer, 2005, p. 320).

The others' definitions

To define a thing is to substitute the definition for the thing itself.
(G. Braque)

How do the others define sustainability? This section provides an overview concerning the other disciplines' definitions and conceptualizations of the notion "sustainability".

One of the most basic definitions determines sustainability as maintaining programmes' effects over a long period of time (Pluye et al., 2004b). This reflects the World Health Organization's perspective which defines sustainability as "the ability of a project to continue to function effectively for the foreseeable future" (quoted in Amazigo et al., 2007, p. 2071). Similarly, Blasinsky, Goldman, and Unützer (2006) define sustainability "as the continuation of all or part of the program after initial external funding ends (p. 719). Savaya et al. (2009) provide a somewhat more differentiated definition: They apply the notion of sustainability to "both the preservation of program outcomes and the continuation of the program itself" (p. 2).

Some definitions are rather sophisticated and use degree or category models to define the notion of sustainability:

Pluye et al. (2004b) suggest four degrees of programme sustainability: (1) The absence of sustainability; (2) Precarious sustainability; (3) Weak sustainability; and (4) Sustainability through routinization (p. 489). The first degree refers to programmes with no on-going activity. The second denotes sustained programmes, whose future status is uncertain due to actors who "maintain some residual activities on an informal basis as part of their functions in the organization, but this is completely unrelated to the program. The continuation of these activities depends entirely on the initiative of these actors" (ibid.). The third degree refers to programmes, whose sustained activities are weakly maintained: "These activities may be subject to radical changes in the short term" (ibid.). Yet the fourth degree denotes sustained programmes with routinized results.

Sustainability as a question of routinization is already discussed by Yin (1979), who states: "When an innovation has become a stable and regular part of organizational procedures and behavior, it is defined as having become routinized" (p. 55). Similarly, Scheirer (2005) defines "sustainability as the institutionalization or routinization of programs into ongoing organizational systems" (p. 325). So programme activities can be most likely sustained "if the program components become embedded into organizational processes" (ibid.).

Shediac-Rizkallah and Bone (1998; quoted in Johnson et al., 2004, p. 137) use three categories to address the notion of sustainability: (a) maintaining benefits achieved through an initial program, (b) continuing the program within an organization, and (c) building the capacity of the recipient community to continue a program. The first of these categories refers to the basic definition of sustainability (see above). The second category concerns the continuation of programme activities within an organization and corresponds to Pluye et al.'s (2004b) fourth degree "sustainability through routinization" (see above). The third category goes beyond this routinization degree and refers to the continued capacity of a community to develop and deliver innovative programmes. This is also reflected by Johnson et al. (2004), who state: "The system must be receptive to change, thus creating an environment for innovations to adapt to the system, if necessary, to which they are introduced" (p. 137).

There is a number of varied notions in literature that address the issue of sustainability. Johnson et al. (2004, p. 136) list eleven of these terms: confirmation, continuation, durability, incorporation, institutionalization, level of use, maintenance, routinization, stabilization, sustainability, and sustained use. Another literature review by Pluye et al. (2004, p. 121) provides even more notions: adoption, appropriation, colonization, consolidation, durability, embedding, incorporation, integration, longevity, maintenance, nesting, permanence, perpetuation, persistence, routinization, survival, and viability. These and other authors (e.g., Savaya et al., 2009) claim that the most common notion with similar meaning is institutionalization.

Of course, all these notions are not used and conceptualized overall synonymously: different authors use different notions and hold different meanings on them. For example, Johnson et al. (2004) provide a clear distinction between sustainability and institutionalization: "Continued ability of an innovation (infrastructure or program) to meet the needs of its stakeholders is central to the sustainability process. … In contrast, institutionalization refers to the long-term viability and integration of a new program within an organization. … Thus, 'meeting the continual needs of stakeholders' vs. 'integration into business as usual' is one major distinction between the two terms" (p. 136). Yet another example for differentiated use of notions is provided by Pluye et al. (2004): They distinguish routinization and standardization. On the one hand: "Routinization constitutes the primary process permitting the sustainability of programs within organizations and may lead to program-related organizational routines. …. Memory, adaptation, values, and rules define organizational routines" (p. 124). On the other hand: "Standardization constitutes the secondary process permitting the sustainability of programs. This process is superimposed upon the primary process of routinization and may lead to program-related standardized routines that are more sustainable than simple organizational routines. Institutional standards introduce a higher degree of program sustainability" (p. 125).

Another aspect concerning the definition of sustainability is raised by Rogers (2003): He claims that an analysis of sustainable impact should not be limited to effects that were planned at the beginning of the programme; it is also important to examine unintended effects and unanticipated consequences that were not known at the beginning of the programme.

The others' theoretical models

Your theory is crazy, but it's not crazy enough to be true.

(N. Bohr)

How do the others frame the issue of sustainability theoretically? The following section provides an overview regarding the other disciplines' theoretical frameworks modelling innovative programmes' sustainability.

As a result of an extensive literature review, Pluye et al. (2004) state that "the development of programs is often modelled as a linear sequence of phases. The label of these phases may change but the sequence is typically one where planning, implementation, evaluation and sustainability phases follow one another chronologically with minimal overlap. The sustained program is the culmination of this 'stage' model" (p. 126). This statement is supported by an illustrative overview, which provides the various stages used by the respective authors (see Figure 1; ibid.):

Table 2
Illustration of the 'stage' model: empirical studies on health promotion

References of studies	List of phases
Barab et al. (1998)	Adoption
	Implementation
	Institutionalization
Bracht et al. (1994)	Design and initiation
	Implementation
	Evaluation
	Program maintenance
Butterfoss et al. (1998)	Formation of the coalition
	Implementation
	Maintenance
	Outcome and institutionalization
Goodman and Steckler (1989)[a]	Unsatisfied demands, search for response
	Evaluation of alternatives
	Adoption
	Initiation of action
	Implementation
	Institutionalization
Goodman et al. (1993)	Community mobilization
	Development of interventions
	Process outcomes
	Institutionalization
Goodson et al. (2001)	Program development
	Adoption
	Implementation
	Evaluation
	Institutionalization
O'Loughlin et al. (1998)	Awareness of the program
	Adoption
	Implementation (incorporation if needed)
	Institutionalization
Paine-Andrews et al. (1996)	Pre-planning
	Planning
	Implementation
	Institutionalization

Figure 1

Yet another kind of stage model is provided by Savaya et al. (2004), who distinguish different forms of possible programme continuation: A programme can be continued "(a) with similar activities and target groups, (b) with similar activities and new target groups, (c) with similar activities in a different location or community, and (d) with new activities and the same target groups, building on the previous work" (p. 4).

Although stage models are commonly used by various researchers (see Figure above), they are also critically discussed: A "stage model is deceptive in theory and artificial in practice. It suggests that a sustainability phase naturally follows a successful implementation phase. … This model does not take account of the recursive or reflexive character of sustainability and learning or of the continuous adjustments that shape the sustainability process" (Pluye et al., 2004, p. 126). Moreover, within stage models it is rather unclear when and how sustainability can be fostered or assessed: "In a 'stage' model, what is sustained, in theory, prolongs what had been implemented. Thus, sustaining a program consists in finding the means of reinforcing, and making last what had been implemented" (ibid.). Following these considerations, Pluye et al. (2004) propose that programme implementation and programme sustainability are rather concomitant processes than successive phases: "Certain specific events influence sustainability, and others, implementation. Others influence both implementation and sustainability" (p. 127).

Rogers (2003) carried out an extensive review of literature concerning the diffusion of innovations. He proposes that innovations are adopted within social systems through a five-step process, taken by each of the system's individuals: knowledge, persuasion, decision, implementation, and confirmation. In the first step, an individual knows the innovation on a rather superficial level. In the second step, the individual tries to get more information concerning the innovation. In the third step, a decision is made whether or not to adopt the innovation. Then, in the fourth step, the individual implements the innovation within the social system and evaluates whether it is useful. In the last step, the individual feels certain that the adoption and continued use of the innovation is a proper decision. Moreover, Rogers (2003) describes how innovations are adopted by particular typical groups of a social system: They start from innovators (about 3% of the social group's members) and spread from a small group of early adopters (about 13%) over an early majority (another 34%) and the late majority (another 34%) to the laggards (about 16%) of the social system.

The others' research methods

Take a method and try it. If it fails, admit it frankly, and try another. But by all means, try something.
(F. Roosevelt)

How do the others carry out research? The following section deals with the other disciplines' research methods for analysing the sustainability of their programmes' impact.

In general, there is no agreed-on method for how and when to evaluate sustainability: "Research on the general topic of 'what happens after the funding ends' for a specific program is not yet well conceptualized. … Various authors tend to approach the topic in very diverse ways" (Scheirer, 2005, p. 323). Pluye et al. (2004) complain this issue: "it is difficult … for researchers to study" (p. 121).

However, some theoretical frameworks which conceptualize routinization or institutionalization as central aspects of sustainability (see the others' definitions, above) suggest "that studying sustainability requires searching for the presence of organizational routines or institutional standards" (Pluye et al., 2004, p. 125). Within some other frameworks which define sustainability as one (and mostly final) of various stages, the issue of sustainability "requires its own evaluation, apart from and usually after, an evaluation has shown positive results for the program intervention itself" (Scheirer, 2005, p. 344).

A common suggestion to enhance the validity of research results is using methods of triangulation: "Studies of sustainability should make greater use of methods to reduce potential bias in findings, such as contacting multiple respondents to obtain convergence in reports of organizational processes and using multiple sources of evidence" (Scheirer, 2005, p. 344).

Regarding sustainability's time horizon, some studies assess sustainability on the basis of participants' or leaders' projections immediately at the end of a programme. For example, Savaya et al. (2009) state: "At this point, the project leaders presumably had sufficient information to know whether their projects would be continued and in what form" (p. 5). Some other studies use qualitative research methods to document sustainability a certain time span after the programme's termination. For example, Blasinsky et al. (2006) gathered data (documents, observations, and interviews) approximately one year following the end of a particular programme.

The others' fostering factors

Form and function are a unity, two sides of one coin. In order to enhance function, appropriate form must exist or be created.
(I. Rolf)

Which factors promote the sustainability of the others' programmes? The following section provides other disciplines' research findings regarding factors fostering the sustainability of innovations or professional development programmes.

Literature regarding conceptual or empirical knowledge of factors that may foster the sustainability of innovations is rather sparse (Johnson et al., 2004). However, "the question of what factors contribute to or detract from program sustainability is important because … it cannot be assumed that proven success in achieving its goals ensures a program's continuation beyond its initial funding" (Savaya et al., 2009, p. 2). The question which factors help increase the likelihood of sustainability is particularly addressed in literature regarding the institutionalization of programmes within organizations: "This issue is of central importance when one is planning for program sustainability, when it is helpful to know what processes and other influences need to be considered to extend the delivery of program activities" (Scheirer, 2005, p. 324).

This paper uses a qualitative analysis of literature (Mayring, 2003): Eight central factors, which foster the sustainability of programmes, were categorized. The following factors are central, because they were found to be influential more often than other ones: perceived benefit, innovation champions, mutual fitting, institutional support, sufficient resources, networking, ownership, and integration of rules. The following paragraphs provide an overview concerning these central factors.

<u>Perceived benefit</u>

One of the central factors fostering the sustainability of programmes is "the perceived benefit from the programme" (Amazigo et al., 2007, p. 2080) for the people involved. This implies in particular that "attention to the needs, attitudes, and perceptions of adopters is critical to their sustained use of an innovation" (Johnson et al., 2004, p. 143). And further: "Users must perceive a benefit to the innovation beyond that of current practices. … Adopters are also more likely to sustain an innovation

if they believe it is effective" (ibid. p. 145). Baum et al. (2006) state that some "initiatives were often only felt to have happened because of the previous collaborations. ... In effect these had laid the seed bed on which future projects grew" (p. 262).

In particular, the "evidence that the model works … and the ability to document positive client outcomes" (Blasinsky et al., 2006, p. 721) represents a strong fostering factor. On the other hand, Scheirer (2005) highlights that these "benefits to staff members and/or clients … are readily perceived, but not necessarily documented via formal evaluation" (p. 339).

Pluye, Potvin, Denis, Pelletier, and Mannoni (2005) found incentives to be a factor fostering the sustainability of innovations: "The promotion of personnel (into positions of greater responsibility and power) encouraged the routinization of innovations. … Adding concrete benefits to human resources also constitutes an incentive (for example, in the form of convenience or reduced effort)" (p. 125).

Innovation champions

Another central factor that supports the sustainability of programmes is "the presence of champions for an innovation" (Johnson et al., 2004, p. 138). Similarly, Scheirer (2005) highlights "the key role of a program champion" (p. 339). Also Savaya et al. (2009) state that "program champions who promote the program in the organization and the community can contribute to program sustainability" (p. 2).

These champions are "formal and informal leaders within adopting systems … who proactively promote an innovation from inside or outside of a system" (Johnson et al., 2004, p. 143). They "are critical to creating an environment that supports and facilitates sustaining innovations. … Such champions can serve as brokers on behalf of the innovation with other decisionmakers" (ibid.). Johnson et al. (2004) describe in detail: "Essential skills for innovation champions include communicating their commitment to the innovation, … engaging others, overcoming barriers, building infrastructure, thinking and learning reflectively, summarizing and communicating, coaching for sustainability, and building further organizational capacity to spread the innovation" (p. 144).

Blasinsky et al. (2006) point to the importance of staff members who are "already trained [in the programme]" and are "available not only to continue [the programme] but also to train others in the intervention" (p. 726).

Mutual fitting

Yet another central factor fostering sustainability is the fitting of innovations and adopting institutions. For example, "when program objectives fit with the values of the organization and staff" (Pluye et al., 2005, p. 125). Or "when cultural artifacts from program activities are shared with organizational artifacts" (ibid.); here, artifacts are defined as myths, symbols, metaphors and rituals that express a set of organizational values, beliefs and feelings. Another kind of fitting is represented by "the adaptation of activities according to their context or environment" (ibid.); in this case, adaptation means the adjustment of activities regarding local contexts and environmental variations. In sum, this refers to introducing innovations into organisations without "disruption of the operating work flow" (p. 126).

Johnson et al. (2004) state that sustainability is fostered when innovative programmes are "compatible with the philosophical orientation … and internal agenda of users" (p. 145). Similarly, Scheirer (2005) claims for "a substantial fit with the underlying organization's mission and procedures" (p. 339). This challenges both the organisations' stability and flexibility: "The stability of an organization and its ability to change significantly contribute to the sustainability of new programs" (Savaya et al., 2009, p. 2).

Institutional support

Institutional support is another central factor that supports the sustainability of programmes. This can be mirrored by the "willingness of the organization to promote change" (Blasinsky et al., 2006, p. 726). Or when organisations take the risk of supporting innovative programme activities: Because then organisations "build confidence among actors involved in activities and encourage the routinization of programs" (Pluye et al., 2005, p. 124).

For this, the administration of organisations "must have the structures and capacity necessary to carry out administrative functions related to an innovation responsively, effectively, and efficiently" (Johnson et al., 2004, p. 144). In this regard, it is important to know that "systems that focus on strengthening administrative capacity to support an innovation during its initial implementation are more successful at sustaining the innovation once the initial trial ends" (ibid.).

Sufficient resources

Yet another central factor fostering sustainability is the availability of resources. Johnson et al. (2004) state that "sustainability research clearly identifies resources as important to sustaining innovations" (p. 143). These resources include human, physical, technological, financial and informational resources (Pluye et al., 2005; Johnson et al., 2004). Sufficient resources can support the sustainability of programmes in the case of "equipment turnover (renewal of material resources when needed)" or of "turnover in key personnel (change of original personnel after an appropriate period of time)" (Pluye et al., 2005, p. 124). To ensure the availability of sufficient resources, programmes can "have multiple sources of funding", and/or "the project leaders can plan to raise resources for the future, when fund raising starts early on" (Savaya et al., 2009, p. 2).

Networking

Savaya et al. (2009) highlight the importance of networking: "Self-contained programs are less likely to be sustained than are programs that are well integrated with existing systems" (p. 2). In this regard, Pluye et al. (2005) state "that transparent communication between the actors is necessary to achieve congruence among objectives, to share cultural artifacts, and to take corrective actions, thus promoting routinization" (p. 125). For networking, some "positive relationships among key implementers" (Johnson et al., 2004, p. 138) are useful: "Collaboration between program developers and teachers who are implementing the program appeared to increase their commitment and desire to implement the new procedures. A supportive peer network among implementers of an innovation is also important for sustaining innovations" (ibid.).

Ownership

Savaya et al. (2009) point to the factor ownership as being central for sustainability: They found "greater sustainability of programs that were developed and implemented with the involvement and support of community bodies" (p. 2). Also Johnson et al. (2004) indicate the importance of "ownership by … system stakeholders" (p. 138) as factor fostering the sustainability of innovative programmes. Similarly, Amazigo et al. (2007) point to the fostering influence of "community leaders [who] show appreciation" (p. 2080) for the programmes.

Integration of rules

Research findings of Johnson et al. (2004) suggest that the integration of rules is another fostering factor: "Policies and procedures … assure that the innovation remains part of the routine practice of the organization, even after the top management who advocated sustaining the innovation leaves the organization. (p. 143). For Yin (1981), sustainability is fostered when "program functions become part of job descriptions and prerequisites" or when "the use of innovation becomes part of statute, regulation, manual, etc." (p. 63).

The others' hindering factors

Avoid problems, and you'll never be the one who overcame them.
(R. Bach)

Which factors hinder the sustainability of the others' programmes? The previous section provided an overview regarding the other disciplines' fostering factors. Of course, one can consider the non-occurrence of a fostering factor as a hindering factor per se. The following section goes beyond this consideration and provides the others' findings dealing explicitly with factors hindering the sustainability of programmes or innovations.

One major hindering factor is staff turnover: "If there is turnover of the initial program director or champion, and the implementing organization does not continue the training and support after the initial implementers leave" (Scheirer, 2005, p. 340). Similarly, Slavin (2004) states: "Innovations are often brought in or championed by … a small number of staff members, and a program may disappear when these people move on" (p. 61).

Another factor that hampers sustainable impact of innovations or programmes is represented by organizational or structural barriers. Blasinsky et al. (2006) state that "the inability or resistance of health care organizations to change their systems of care" (p. 725) is a crucial obstacle.

Financial issues represent yet another hindering factor. For example, Blasinsky et al. (2006) claim that "despite the fact that the program model worked well, … it was not possible to overcome the barriers of funding issues" (p. 725). In some cases, it is not the mere amount of money that influences sustainability: Slavin (2004) found that "even programs that do not cost much may still disappear when funds are cut, as [people involved] cut back on professional development or materials budgets, or simply become demoralized" (p. 61).

Pluye et al. (2005) point to the recognition of failure as a hampering factor: "Failed or ineffective activities, when recognized, hinder routinization. …Failure to deliver activities hampers the ends of routinization, because the organization then reinforces its traditional activities, which are considered sure to succeed" (p. 125).

The others' discussion

A scientist's aim in a discussion with his colleagues is not to persuade, but to clarify.
(L. Szilard)

How do the others discuss their research findings? In this section, some exemplary lines of discussion are provided.

In general, the research findings are not convergent or clear-cut: "Research on the topic of program sustainability, although greatly needed, is not likely to develop and validate a single set of guidance about 'how to do it'. … It is likely to remain multifaceted, with results contingent on the specific programs and contexts in which they are operating" (Scheirer, 2005, p. 325).

Some results are "are counterintuitive and inconsistent with the literature" (Savaya et al., 2009, p. 13) and point to rather paradox situations: "It may be conjectured that the more effective a project is, the less needed it seems to be and the less reason there seems to be to continue it. Conversely, less effective projects may give rise to the expectation that efforts will be made to persevere until they attain their aims" (ibid.).

The other disciplines discuss the question of how and when integration of sustainability issues in programme planning is reasonable and necessary: "Decision-makers involved in implementing an innovation must face the ultimate challenge of planning for the time when the implementation phase is completed" (Johnson et al., 2004, p. 136). But when should this planning take place? Pluye et al. (2005) suggest: "The planning of sustainability begins at the very start of programs. This reflexive approach departs from the recommendations suggested by the stage model … in which sustainability is only considered after programs are implemented" (p. 135). Similarly, Scheirer (2005) postulates early planning and formative evaluation of programme sustainability: "The timing of evaluation findings is often too late in the project life cycle to be useful in promoting sustainability; evaluation could be more useful if it included continuously accumulated data about major outcomes, so that interim data about outcomes would be available before the initial funding ends" (p. 344).

The other disciplines clearly note that sustainability is not a value per se. In some cases, it is not only non-essential, but rather not desirable or worthwhile: "Not all innovations need to be continued because circumstances, people, situations, and problems change. … Further, an effectiveness evaluation may find that an innovation does not work outside of specific controlled conditions" (Johnson et al., 2004, p. 136). It is recommended that "a sustainable innovation should be proven to be of benefit to the diverse stakeholders (users of the innovation) prior to adoption" (ibid., p. 138).

Yet another discussion line is of epistemological nature: If research provides results, how can we know that we got it right? This is a question of validity. Van den Berg (2005) discusses the question of causal linkages between programme and sustainable impact: "By definition these linkages grow weak beyond the immediate reach of the activities and become more hypothetical in nature. … But if attribution is reduced to the idea that the outcomes are 'just one of many factors contributing to a certain impact', then we might ask: is it all worthwhile? Should we spend a lot of money on an evaluation that will not establish attributable impact?" (p. 29).

Another rather general obstacle for sustainability is discussed by Pluye et al. (2004): "Traditionally, institutions are stable, and institutional changes are rare and come about in a radical manner after the mobilization of the population or after hierarchical, authoritarian decisions" (p. 125).

Facing forward, the others plea for further research on the issue of innovations' and programmes' sustainability: "It is strongly needed to consolidate empirical evidence and to test strategies aimed at increasing the numbers of sustained programs" (Scheirer, 2005, p. 325). And: "Funders should continue to provide support for evaluation to go beyond the usual focus on ascertaining effectiveness to grapple with these longer term issues of sustainability" (ibid, p. 342).

Discussion and implications

Always desire to learn something useful.
(Sophocles)

This section links the others' respective categories (rationales, definitions, theories, methods, factors, and discussions) to mathematics teacher education. Communalities can indicate possible affirmations and validations of our discipline's knowledge. Differences may point to aspects worth being challenged and reconsidered. In the following, each category is discussed and possible implications are suggested.

Discussion and implications of rationales

The other disciplines state that knowledge about sustainability is rather contradictionary (see the others' rationales above); however, teacher education's knowledge base is too scarce to be compared and judged as convergent or inconsistent. Therefore, further research on this issue is strongly recommended, from the perspective of both scholarship and practice.

An obstacle indicated by the others is that "Impact assessments … are too costly" (see above). Similar arguments are hindering research in the mathematics teacher education domain: In most cases, after the end of a particular programme, the funders' focus (and funding) shifts to new projects; time and money are invested in a new project, which limits or terminates the financial and administrative possibilities of the previous programme: "Reformers and reform advocates, policymakers and funders often pay little attention to the problem and requirements of sustaining a reform, when they move their attention to new implementation sites or end active involvement with the project" (McLaughlin & Mitra, 2001, p. 303). However, from a financial perspective, it would make sense to analyse the long-term and sustainable effects: "Too many resources are invested in professional development to ignore its impact over time" (Loucks-Horsley et al., 1996, p. 5). Therefore, the classical financial argument (against the research of sustainability) should be objected and not be any more left without contradiction.

The research questions of the other and the teacher education disciplines are often similar or the same. Therefore, the respective research projects may be highly interesting for each other and should be received accordingly.

Discussion and implications of definitions

The other disciplines are using degree or category models to conceptualize sustainability (see the others' definitions above). The teacher education disciplines use similar models, for example a stage model called "hierarchy of sustainability" (Seufert & Euler, 2004): At stage 1 an innovation is sustained due to a social group's own interest, to obtain the material benefits of the programme. Seufert and Euler (2004) call this level project-oriented sustainability and emphasize that this level implies the risk of isolated island solutions due to a lack of development perspectives. At stage 2, an innovation is maintained not only by those directly involved, but leads to an efficiency increase of the entire system. Fullan (2006) refers to this as lateral capacity building; Seufert and Euler (2004) call this level system-oriented sustainability. While expanding the perspective beyond the immediate programme boundaries, however, this level "neglects the emergence of a future-oriented problem-solving potential to increase the performance and innovation capability of the organization" (Seufert & Euler, 2004, p. 10). At stage 3, the innovation leads to behavioral changes which allow the involved individuals or organizations to respond flexibly and appropriately to environmental conditions. Thus innovations implemented during the programme can be adapted accordingly. Seufert and Euler (2004) refer to this as potential-oriented sustainability.

Two components of sustainability can be distinguished: On the one hand, sustainability refers to structures, rules, knowledge, attitudes or practices; thus the resources and potentials, which were created during the programme period. On the other hand and in addition to this structural component, the functions of these potentials are in the focus, when the programme and the associated external support come to an end. The issue here is not primarily about problem-solving, but rather about the development of a problem-solving capacity. In this regard, Fullan (2006) states: "Sustainability requires continuous improvement, adaptation and collective problem solving in the face of complex challenges that keep arising" (p. 119). In this context, sustainability means "changes in practice and deepening understanding in ways that keep vital practice, responsive to changes in students, subject area content and classroom contexts" (McLaughlin & Mitra, 2001, p. 304). This dynamic component is particularly reflected at stage 3 (see above). Therefore, it seems reasonable that professional development programmes should define and aim at enhancing this potential-oriented sustainability.

Given the various and diversified definitions of sustainability (see the others' definitions above), one can discuss which of the different conceptualisations should be particular goals of professional development programmes. For example, Scheirer (2005) claims that routinization has not necessarily to be an intended outcome of the life cycle of a programme. Moreover, she suggests instead that "capacity building and innovativeness generated by the development of new programs is the more important outcome that should be sustained" (p. 324). In the domain of teacher education disciplines, Hargreaves and Fink (2003) state: "Sustainability is more than a temporal matter" (p. 2). Similar to Scheirer (2005), they hold a differentiated perspective on the notion: "Sustainability does not simply mean whether something will last. It addresses how particular initiatives can be developed without compromising the development of others in the surrounding environment now and in the future" (Hargreaves & Fink, 2006, p. 30). This meaning of sustainability causes various effects: Firstly, it means promoting more broad-based programmes with benefit for many people and organizations, rather than encouraging short-term and small-bounded programmes: "Sustainable improvement demands committed relationships, not fleeting infatuations" (Hargreaves & Fink, 2003,

p. 3). This means in particular to aim at impact that enables people to promote innovations and change independently: “Sustainable improvement requires investment in building long term capacity for improvement, such as the development of teachers’ skills, which will stay with them forever, long after the project money has gone” (ibid). Similarly, Fullan (2006) defines sustainability in the regard of educational change as “the capacity of a system to engage in the complexities of continuous improvement consistent with deep values of human purpose“ (S. 114). In sum, the potential for self-renewal is the focus: Sustainability means that people and institutions react autonomously to changing conditions; they generate and apply new processes and products according the respective new conditions. At least, the great number of definitions and conceptualizations shows the interest of research and practice in this topic: “This profusion of terminology is testament to the significant desire for better comprehension of the phenomenon” (Pluye et al., 2004, p. 121). Therefore, projects researching the impact of innovations or professional development programmes should clearly reflect and consider which perspective and meaning of sustainability is informing the analysis.

Another aspect of the definition of sustainability is the time horizon. Most definitions have in common the continued focus on long-term impact. But at the same time it remains unclear how long “long-term” may be. It remains unclear whether sustainability is given after one month or after ten years of permanent continuation “There is no commonly accepted time point for defining when a program is sustained” (Scheirer, 2005, p. 334). When is it reasonable to call some changes sustainable? “At times, the time horizon of sustainability is so broad (in extreme cases indefinite), that evaluation of sustainability is administratively impossible" (Stockmann, 1993, p. 27). Therefore, each examination of lasting impact necessarily has to define what time period is encompassed by the term sustainability.

Whereas some innovations are adopted rather quickly, some other change processes need more time to be carried out. The reasons for this are manifold. For example, “there might be a tendency to keep staff members on the payroll for a time, to maintain only some activities of a broader initiative, or to keep a recent initiative going for political or face-saving reasons, even if it is not sustained permanently” (Scheirer, 2005, p. 334). Therefore, each innovation that aims to be sustained has to carefully reflect this issue.

The occurrence and analysis of not intended impacts (besides the intended ones) is not very common in the other disciplines (see above). Similarly, the teacher education disciplines do not distinguish intended or not intended, expected or not expected impact within their definitions of sustainability (Zehetmeier, 2008). An impact analysis that only evaluates intended and expected effects remains incomplete in the sense of a nominal-actual value comparison. Therefore, sustainability definition and research need to take systematically into account the unintended and unexpected impacts.

Discussion and implications of theories

The other disciplines use various theoretical frameworks to model the sustainability of impact (see the others’ theories above). When analysing teachers’ professional development, the question of possible levels of impact is important. Many papers which deal with teachers’ professional development put teachers’ learning in the main focus (see e.g., Guskey, 2000; Lipowsky, 2004, 2010; Sowder, 2007; Zehetmeier, 2008). The major categories for describing teachers’ learning are their beliefs, knowledge, and practice (Zehetmeier, 2011). The IPD model (Impact of Professional

Development model; Zehetmeier, 2009) comprises a rather wide range of possible levels of impact: The categories knowledge, beliefs, and practice are used to analyse the impact on the teachers' level as well as on other in-school and beyond-school levels. Within this model, the core elements that constitute professional development activities are the teachers, the facilitators, the programme itself, and the context which embeds the former three (Borko, 2004). The IPD model also provides the mediating factors that foster the professional development programme's impact.

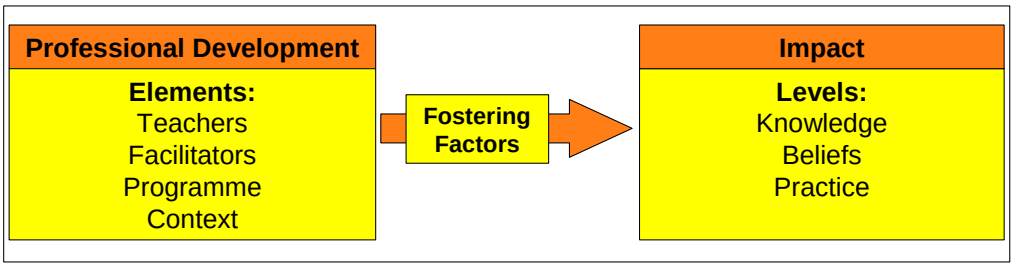

Figure 2: The IPD-model

Knowing the theoretical frameworks may help researchers and practitioners to better understand an innovation or programme becoming sustainable (or not). Therefore, it seems reasonable for both, scholarship and practice to know possible frameworks and to make use of them. For example, the knowledge about the existence of innovators, early adopters, early majority, late majority, and laggards (Rogers, 2003; see the others' theories above) as types of adopters, can help to effectively cooperate with the respective types.

While the IPD model is well suited as a tool to describe the impact of professional development programmes, it remains open, how to explain and theoretically frame causal linkages. The question arises, whether the described impact is really due to the particular professional development programme, or due to some other sources (which may be the case). Van den Berg (2005) discusses this issue: "The question of causality is central to establishing impact. The model that evaluations have used in this regard is that of causal linkage, allowing for attribution of observed changes to the intervention" (p. 30). However, this emphasis on causal linkages may lead to the (public) opinion "if no causal linkage can be established, perhaps we should stop it". Thus, van den Berg (2005) suggests to carefully analysing what casual linkage may mean: The common concept of cause in grounded in physics, where a causal relationship refers to a linkage that has been established both theoretically and empirically. However, teacher education cannot refer to causality as something that is established through existing scientific theories, since there are too many activities and circumstances for any general causality to be established: "We seem to lack general causality and we need to restrict ourselves to specific causality" (ibid., p. 31). Van den Berg (2005) states further that there is one exemplary field of expertise particularly interested in describing the multitude of specific events and that is history: "Historians are thus interested in the circumstances and events that caused other events to take place as they did. … Many evaluations tend to be historical in nature … in the sense that they describe what happened and why, rather than carrying out systematic scientific assessments of the linkages between interventions and changes in society" (p. 32).

In sum, there is a wide variety of meanings of the notions causality and linkage. If research on programmes' sustainability uses a rigorous approach which considers many factors contributing to impact, then therefore the term contribution should be preferred (rather than causal linkage). In this regard, van den Berg (2005) proposes that research "should move from the concept of linear causality to the concepts of conditionalities (necessary but not sufficient conditions for changes to occur). Furthermore, it should be made clear that these necessary but not sufficient conditions contribute to rather than cause the change to take place" (p. 34).

Discussion and implications of methods

The methods used by the other disciplines do not have any gold standard method to research the sustainability of programmes. Within the teacher education disciplines the tradition and experience with this kind of research are rather limited (Datnow, 2006); thus there is no standardised agreed-on method. Many research projects (e.g., Zehetmeier & Krainer, 2011) follow a case study design (Yin, 2003), since this approach seems particularly suited for analysing the impact of innovations: "The usual survey research methods are less appropriate for the investigation of innovation consequences. […] Case study approaches are more appropriate" (Rogers, 2003, p. 409). Similarly, Hancock and Algozzine (2006) state: "Through case studies, researchers hope to gain in-depth understanding of situations and meaning for those involved" (p. 11). This implies the use of methods of triangulation, which is common in both the other and teacher education disciplines. Triangulation comprises data from various sources and time periods to gain validity by "convergence of evidence" (Yin, 2003, p. 100). Similarly, Scheirer (2005) recommends: "Researchers publishing articles about sustainability should be sure to fully document their methods for data collection and analysis, so that the likely validity of their findings can be assessed in relation to the methods used in each study" (Scheirer, 2005, p. 344). Therefore, the use of qualitative research methods, in particular of case studies with triangulated data, seems a reasonable method for analysing the sustainable impact. This does not mean to exclude quantitative data; rather it suggests combining qualitative and quantitative data within a mixed methods setting. This can lead to differentiated evidence from various perspectives: Quantitative surveys' results provide an overview, and qualitative analyses' findings lead to a mosaic of particular cases. Both the overview and the mosaic together can help to better understand the sustainable impact of teacher professional development programmes (Zehetmeier, 2011).

Discussion and implications of factors

The other disciplines identified several factors that foster or hinder the sustainability of programmes (see the others' factors above). In a meta-analysis concerning factors in the teacher education disciplines, Zehetmeier (2008) found yet similar, but not the same factors. For example, mutual fitting, ownership, and networking turned out to be central fostering factors in both the others' and teacher education literature. Therefore, is seems reasonable to facilitate factors identified by both domains.

Zehetmeier and Krainer (2011) highlight in particular the outstanding relevance of contextual factors. Similarly, a study of Nickerson and Moriarty (2005) points to organizational conditions (e.g., teachers' relationships with the school administration) being highly relevant for the further development of schools. Since contextual factors contribute particularly to sustainable impact, organisational

development should be part of any professional development programme. This means, that not only mathematics teachers should be seen as a programme's target group, but also the teachers' contexts (e.g., colleagues, pupils, principals, parents, policies, etc…). Therefore, professional development and school development should be considered as concomitant processes.

Rogers (2003) highlights that the diffusion of an innovation depends on different characteristics: Relative advantage, compatibility, complexity, trialability, and observability. Fullan (2001) describes similar characteristics (need, clarity, complexity, quality, and practicality) influencing the acceptance and impact of innovations. Relative Advantage includes the perceived advantage of the innovation (which is not necessarily the same as the objective one). Compatibility and need denote the degree to which the innovation is perceived by the adopters as consistent with their needs, values and experiences. Complexity and clarity include teachers' perception of how difficult the innovation is to be understood or used. Trialability denotes the opportunity of participating teachers to experiment and test the innovation (at least on a limited basis). Quality and practicality make an impact on the change process. Observability points to the claim that innovations should be visible to other stakeholders. Therefore, when aiming at sustainable impact, the following implications should be considered: An innovation with greater relative advantage will be adopted more rapidly. More complex innovations are adopted rather slowly, compared to less complicated ones. Innovations that can be tested in small steps represent less uncertainty and will be adopted as a whole more rapidly. High quality innovations that are easily applicable in practice are more rapidly accepted. Innovations which are visible to other persons and organisations are more likely to be rapidly accepted and adopted.

Shediac-Rizkallah and Bone (1998) categorized three groups of factors that foster or hamper programmes' sustainability: (a) factors pertaining to the project; (b) factors within the organizational setting, and (c) factors in the broader community environment. Zehetmeier and Krainer (2011) try to reduce the multiple factors' complexity by clustering them into three dimensions (the three Cs; see Krainer, 2006): Content (high level and balance of subject-related action and reflection), Community (high level and balance of individual and social activities, in particular fostering community-building within and outside the professional development programme), and Context (high level and balance of internal and external support). Thus, both domains acknowledge the rather complex system of factors and try to establish useful and suitable models. Therefore, if professional development programmes are aimed to be sustainable, it seems crucial to carefully consider and facilitate these fostering and hindering factors. If some of these factors are dependent from the programmes' existence, then these factors may be substituted with alternative ones that are less or not at all connected to the programmes' existence.

Leadership as fostering or hindering factor is not really a topic in the others' disciplines. Indeed, Johnson et al. (2004) point to "effective leadership" (p. 138) being a fostering factor. However, it remains unclear, what this notion may mean. By contrast, within the teacher education disciplines the issue of leadership is of great importance. The results of several studies suggest the central influence of school leadership to the (sustainable) impact of school innovation initiatives (e.g., Fullan, 2006; Owston, 2007): Fullan (2006) proposes a direct correlation between the sustainability of innovations a the new role of school leadership: "This new leadership, if enduring, large scale change

is desired, needs to go beyond the successes of increasing student achievement and move toward leading organizations to sustainability"(p. 113). These new leaders focus on systemic relationships to foster sustainability not only on the individual level, but also on the levels of organisations or educational systems. "Such leaders widen their sphere of engagement by interacting with other schools in a process we call lateral capacity building. When several leaders act this way they actually change the context in which they work" (ibid.). Fullan (2006) calls this new type of leadership "system thinkers in action" ("they have the capacity to be simultaneously on the dance floor and the balcony", p. 114). Similarly, Owston (2007) states: "Support from the school principal is another essential factor that contributes to sustainability" (p. 70). He distinguishes three types of administrative support: Neutral leaders (who meet innovations rather passive without promoting or prohibiting); Supportive principals (who create and support beneficial environments for innovations); And actively involved leaders (who are driving visionary ideas, identify personally with innovations and motivate other teachers for the innovation). Therefore, for programmes aiming at sustainable impact, it seems indicated to foster and support this kind of leadership; particularly regarding related hindering factors like staff turnover or organizational barriers (see the others' hindering factors, above), this issue becomes highly relevant.

Another felicitous sentence concerning the complexity of fostering and hindering factors is provided by Slavin (2004): "With the many ways that innovations can be undone, it is perhaps more surprising when they do maintain over time than when they do not" (p. 61). Therefore, each programme has to carefully consider its respective fostering factors regarding the sustainability of impact, since each professional development programme has its own and particular objectives, contents, methods, and environments. Considering these factors in the programme's planning may help to establish sustainable impact.

Summary and outlook

The future influences the present just as much as the past.
F. Nietzsche

This paper is about the sustainability of professional development programmes. Therefore, it provides the knowledge of other disciplines to discuss possible implications for mathematics teacher education. A literature review reveals the others' rationales, definitions, theories, methods, factors, and discussions. With regard to teacher professional development programmes the following implications can be deduced. The main recommendations for mathematics teacher education are:

Teachers, facilitators, and researchers of professional development programmes should

- during planning
    - plan for sustainability from the very start,
    - clearly reflect which meaning of sustainability is informing the activities,
    - know theoretical frameworks and to make use of them,
    - define what time period is encompassed by the term sustainability,
    - take systematically into account the unintended and unexpected impacts,

- during implementation
    - know and facilitate (or avoid) fostering (or hindering) factors,
    - consider professional development and school development as concomitant processes,
    - focus on factors that are less dependent from the programme's existence,
    - aim at potential-oriented sustainability,
    - foster and support sustainable leadership,
    - be prepared for staff turnover,
    - receive and use other disciplines' knowledge,
- during evaluation
    - reject the classical financial arguments against the research of sustainability,
    - gather data during, at the end, and some while after the programme,
    - combine qualitative and quantitative methods within a mixed methods setting,
    - use methods of triangulation,
    - aim for contributions rather than causal linkages,
    - promote further research on the issue of professional development programmes sustainable impact.

Programmes which consider and accept these recommendations are likely to produce a higher rate of sustainable impact.

When discussing and researching professional development programmes' sustainable impact, the fostering and hindering factors are playing the central role. Knowing and being sensible for them is prerequisite for any conceptualization, implementation and evaluation of future professional development programmes which aim at sustainable impact.

Thus, further, broader as well as deeper research of professional development programmes' sustainable impact and their respective fostering and hindering factors appears to be promising from both scientific and practical perspectives.

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